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Transfer and Non-Transfer Patients in Isolated Low-Grade Blunt Pediatric Solid Organ Injury: Implications for Regionalized Trauma Systems

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Abstract

Background—Regionalization of trauma care is a national priority and hospitalization for blunt abdominal trauma, that may include transfer, is common among children. The objective of this study was to determine whether there were differences in mortality, treatment, or length of stay between patients treated at or transferred to a higher level trauma center and those not transferred and admitted to a lower level trauma center.

Methods—Cohort from Washington state trauma registry from 2000-2014 of patients 16 years or younger with isolated Grade I-III spleen, liver, or kidney injury.

Results—Among 54034 patients 16 years or younger, the trauma registry captured 1177 (2.2 %) patients with isolated low grade solid organ injuries; 226 (19.2%) presented to a higher level trauma center, 600 (51.0%) presented to a lower level trauma center and stayed there for care, and 351 (29.8%) were transferred to a higher level trauma center. Forty patients (3.4%) underwent an

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abdominal operation. Among the 950 patients evaluated initially at a lower level trauma center, the risk of surgery did not differ significantly between those who were not transferred compared to those who were (RR 2.19 95%CI 0.80-6.01). The risk of total splenectomy was no different for patients who stayed at a lower level trauma center compared to those who were transferred to a higher level trauma center (RR 0.84 95%CI 0.33-2.16). Non-transferred patients had a 0.63 (95% CI: 0.45-0.88) times lower risk of staying in the hospital for an additional day compared to patients who were transferred to a higher level trauma center. One patient died.

Conclusion—Few pediatric patients with isolated low grade blunt solid organ injury require intervention and thus may not need to be transferred; trauma systems should revise their transfer policies. Prevention of unnecessary transfers is an opportunity for cost savings in pediatric trauma.

Level of Evidence—III, Epidemiological

Keywords

Secondary Overtriage; Blunt Solid Organ Injury; Splenectomy; Transfer; Regionalized Trauma System

Background

The Institute of Medicine Committee on the Future of Emergency Care declared that regionalization of emergency and trauma care is a national priority.[1] The Committee recommended promoting cooperation between hospitals optimized with resources for emergency and trauma care and hospitals with less robust resources to ensure that patients receive “the right care at the right place at the right time.”[1]

Blunt abdominal trauma is a leading cause of injury requiring hospitalization for pediatric patients. In trauma systems, such patients are often transferred to regionalized trauma centers for care. Mortality is overall lower for injured children when treated at pediatric trauma centers compared to adult, or mixed adult and pediatric trauma centers.[2] For traumatic spleen injuries, rates of splenectomy were found to be lower at children's hospitals compared to general hospitals after adjustment for patient and injury characteristics.[3] These data bolster permissive transfer protocols. However, ensuring patients are cared for at a facility with the appropriate expertise should be continually balanced against the cost of transfer, the physical toll on the patient, inconvenience to caretakers, and optimal resource allocation. This balance may be most relevant for patients with lower grade solid organ injury, where the likelihood of needing operative intervention is low.[4,5]

The primary aim in this study was to determine whether there were differences in mortality, treatment, or length of stay between patients treated at or transferred to a higher level center and those not transferred and admitted to a lower level center. If there were no clinically important differences in outcomes, transferring stable children with lower grade solid-organ injuries from a lower level trauma center to a higher level center for care may not be necessary.

Methods

Setting

The 1990 Washington State Trauma Care Systems Act established a regional system for injury care that included designations for trauma and rehabilitation services, verification of pre-hospital services, field triage criteria development, and quality assurance programs.[6] All hospitals managing trauma are classified into one of five levels of trauma care. Adult and pediatric trauma centers have identical anesthesiology and operating room requirements across levels 1-3, respectively. Pediatric critical care capabilities are required at level 1 and 2 pediatric trauma centers.[7] Level 4 and 5 centers are designated for hospitals that care for both adult and pediatric patients, but not pediatric trauma patients only. The Washington State Pediatric Consultation and Transfer Guidelines recommend transfer to a Level 1 or 2 trauma center for children with any “significant blunt injury to the chest or abdomen” or “if the patient requires ICU management.”[8]

Study Design and Data Source

This is a retrospective cohort study using the Washington State Trauma Registry for the years 2000-2014. Every one of the 82 designated trauma facilities in the state are required to submit data for all trauma patients <15 years old and for patients 15 years or older for hospitalizations lasting longer than two days.[9] De-identified data were obtained from the Washington State Trauma Registry after approval of exempt status by the Washington State Institutional Review Board.

Subjects

We identified pediatric trauma patients aged 16 years or younger with isolated low-grade blunt solid organ injury. The Washington State Pediatric Transfer Guidelines define pediatric patients as age 14 years or younger. Additionally, the guidelines caution physicians on treating larger teenagers as adults given emotional and physical needs akin to children.[8] Ages 15 and 16 years-old were included in the study to account for this practice. We defined low-grade spleen, liver, and kidney injuries using the American Association for the Surgery of Trauma (AAST) grading system as Grade I, Grade II, and Grade III using Abbreviated Injury Score (AIS) provided by the registry and International Classification of Diseases, Ninth Revision (ICD-9 CM) codes for spleen (865), liver (864), and kidney (866).[10] Exclusions included concomitant traumatic brain injury (TBI) as defined by International Classification of Disease Ninth Revision Codes (800.0-801.9, 803.0-804.9, 850.0-854.9, 959.01, and 995.55), extremity and spine fractures, more than two rib fractures or other thoracic injury, colon and small bowel injury, pancreatic and biliary injury, and bladder or genital injury. All procedure and diagnosis codes were reviewed to ensure that proper inclusion and exclusion criteria were met.

Patient Characteristics

We extracted patient data including age, sex, race, and payer. Injury data included year, hospital trauma center designation, transfer status, organ injury, organ-specific AIS, overall injury severity score (ISS), emergency department vital signs, procedures, intensive care unit

(ICU) admission, ICU length of stay (LOS), and overall LOS. Vital signs were categorized based on age-specific normal values.[11,12] Patients were categorized into one of three groups: non-transfer patients who received care at a Level 1 or 2 trauma center, non-transfer patients who received care at a Level 3 through 5 trauma center, or patients transferred from a lower level trauma center (Level 3-5) to a higher level trauma center (Level 1 or 2).

Outcome Measures

The primary outcomes were differences of in-hospital mortality, type of treatment (operative vs non-operative), and length of stay among the three groups of patients.

Statistical Analysis

Descriptive statistics and categorical comparisons based on transfer status were performed. Restricting our analysis to transfer patients and non-transfer patients treated at Level 3-5 trauma centers, we used multiple generalized linear models with Poisson distribution and robust standard errors to evaluate the association between length of stay and transfer status and the risk of transfer by injured organ (spleen, liver or kidney) adjusting for age, ISS, AIS, injury, and year. To assess the risk of surgery by transfer status, we used the same Poisson model and additionally adjusted for organ injured. We used Poisson regression with robust standard errors to estimate the risk of total splenectomy among all spleen injured patients, and among only those undergoing an operation, comparing patients that stayed at Level 3-5 trauma centers to patients who were transferred adjusting for AIS, ISS and year. Given the limitations of large, multi-year administrative datasets in identifying specific isolated injuries, and the potential staffing differences between Level 5 and Level 3 trauma centers, we performed a sensitivity analysis by excluding patients seen at Levels 4 and 5 trauma centers, patients with ISS > 15, or those with a GCS ≤ 8, and patients with Grade III injuries. All tests were two-sided and statistical significance was set at $\alpha = 0.05$. All analyses were performed in Stata/MP software (version 13.1; StataCorp).

Results

The Washington State Trauma Registry captured 54,034 patients aged 16 years or younger who were admitted to a hospital between 2000 and 2014 with 1177 (2.2 %) having isolated low grade solid organ injuries. Overall, 19.2% presented directly to a Level 1 or 2 trauma center, 51.0% presented to a Level 3-5 trauma center and stayed there for care, and 29.8% were transferred from a lower level trauma center to a Level 1 or 2 trauma center (Table 1). Of 951 (80.0%) patients initially evaluated at a Level 3-5 trauma center, 36.9% were transferred to a Level 1 or 2 trauma center (Figure 1). Compared to the group that arrived and stayed at a Level 3-5 trauma center, patients in the transfer group were more frequently in the younger age categories, had ISS scores from 9-16 (49.0% vs. 28.2%, $p < 0.001$), and had liver injuries (37.0% vs. 23.8%, $p < 0.001$).

Few patients had hypotension or bradycardia in the emergency department and the proportion did not differ between groups (Table 2). Nearly all patients were neurologically normal in the emergency department (GCS 14-15). Forty patients (3.4%) underwent an abdominal operation; nine (4.0%) were in the non-transfer Level 1 or 2 group, 25 (4.2%)

were in the non-transfer Level 3-5 trauma center group, and six (1.7%) were in the transfer group ($p=0.09$). Patients staying at a Level 3-5 trauma center were more likely to have a hospital LOS less than 24 hours, while those treated at Level 1 and 2 centers were more likely to have LOS>72 hours (Table 2). Patients who were not transferred had a 0.63 (95% CI: 0.45-0.88) times lower risk of staying in the hospital an additional day (24 hours) compared to patients of the same age, ISS, AIS, injury type and year who were transferred from a higher level trauma center (Table 3). After adjustment for age, AIS, and ISS, patients with solid kidney or liver injuries were 1.28 (95% CI 1.01-1.63) and 1.51 (95% CI 1.26-1.80) times more likely to be transferred compared to patients with spleen injuries, respectively (Supplemental Digital Content Table 1).

Overall, 33.7% of 1177 patients were admitted to the ICU. Eighty-three percent of transfer patients and 81% of patients arriving directly to a Level 1 or 2 trauma center were discharged from the ICU in less than 48 hours ($p=0.28$) (Figure 2). Among the transfer patients, three (1.2%) of 260 with normal vital signs in the emergency department and three (3.3%) of 91 with abnormal vital signs underwent an abdominal operation ($p=0.18$). For patients arriving and staying at a Level 3-5 trauma center, 3.8% of 419 with normal vital signs and 5.0% of 181 with abnormal vital signs underwent an abdominal operation ($p=0.52$). One patient presented to a high level trauma center via private vehicle with hypotension and bradycardia from presumed hemorrhage due to a liver injury, underwent no procedures and expired in less than one hour.

Among the 950 patients evaluated initially at a Level 3-5 trauma center, the risk of surgery was no different for patients who were not transferred compared to those who were, adjusted for organ injured, age, ISS, AIS and year (RR 2.19 95% CI 0.80-6.01). Twenty-six patients had splenic trauma and underwent surgery, of whom four arrived and stayed at a Level 1 or 2 trauma center, 19 arrived and stayed at a Level 3-5 trauma center, and three were transferred ($p=0.277$). Nine patients underwent splenic repair (2; Level 1 or 2 trauma center, 6; Level 3-5 trauma centers, 1; transferred), and there were 16 total splenectomies performed (1: Level 1 or 2 trauma center, 13: Level 3-5 trauma centers, 2: transferred). The risk of total splenectomy was no different for patients who stayed at Level 3-5 trauma centers compared to those who were transferred to a higher level after controlling for age, AIS, ISS, and year (RR 0.84 95% CI 0.33-2.16 among operative spleen injuries and RR 2.26 95% CI 0.42-12.04 among all splenic injuries). Details for all patients who underwent abdominal operation are presented in Supplemental Digital Content Table 2.

Sensitivity analyses excluding Level 4 and 5 centers, excluding Grade 3 injuries, and those patients with ISS>15 or GCS<8, did not change the results in meaningful ways. The results are shown in Figure 3.

Discussion

This is the first rigorous evaluation and report of transfer patterns among isolated low-grade blunt pediatric solid organ injury. Overall, survival in Washington State was nearly 100%. A low proportion of patients underwent an abdominal operation (3.4%). Four out of five pediatric patients with an isolated blunt solid organ injury were initially evaluated at a Level

3-5 trauma center and nearly forty percent of those patients were transferred to a Level 1 or 2 trauma center. Most transfer patients admitted to the ICU were admitted for less than 48 hours. Non-transfer patients had a 37% lower chance of staying an extra day in the hospital compared to similarly aged and similarly injured transfer patients in the same year. This may reflect transportation issues related to being hospitalized farther from home. While more total splenectomies occurred among patients who arrived and stayed at a Level 3-5 trauma center compared to those transferred to a Level 1 or 2 trauma center, the risk of undergoing total splenectomy was not significantly different between the groups. For all patients, the risk of undergoing an abdominal operation was not different for non-transferred Level 3-5 trauma center patients compared to transfer patients.

In an analysis of the Pediatric Emergency Care Applied Research Network (PECARN) that included 12,044 patients under 18 years old from 20 participating sites, there were 212 (1.8%) isolated low-grade blunt solid organ injuries with 3% requiring operative intervention and 1% being transferred out.[13] The injury prevalence and proportion undergoing an abdominal operation found in the PECARN sample is similar to our data from Washington State but the proportion transferred is markedly different, likely due to PECARN's exclusively academic, children's, and urban hospital inclusion.[14,15] Despite this difference in proportion of patients transferred, the similarity in sample characteristics reinforces the generalizability of our results.

Secondary overtriage or unnecessary transfer between hospitals in pediatric trauma is an area of active study but has no established criteria. Goldstein and colleagues reviewed the National Trauma Data Bank for 2008-2011 and defined secondary overtriage as transfer patients with ISS less than 9, who did not undergo a surgical procedure, were not admitted to the ICU, and were discharged in less than 24 hours. These authors discovered 22.4% of transfer patients 15 years or younger satisfied these criteria. [16] Using this definition of secondary overtriage may underestimate overtriage in isolated low grade blunt solid organ injury (4.6% of transfer patients in this cohort) because admission to the ICU in the circumstance of low grade solid organ injury can range from 9% to 73% and may be influenced by hospital protocol.[13,17] Additionally, study findings that being transferred is an independent risk factor for remaining in the hospital obscures the utility of length of stay as a data point for determining transfer necessity in blunt solid organ injury.

Data from Primary Children's Hospital in Salt Lake City, Utah from 2003 to 2013 found 27% of 6380 transfers of pediatric trauma patients to be preventable as defined by length of stay less than 36 hours, no surgical intervention, and no advanced imaging.[18] Using only procedure and length of stay, 16.0% from this cohort met the Utah definition of secondary overtriage. Dartmouth Hitchcock Medical Center evaluated adult and pediatric trauma evaluations from 2007 to 2011 and found that 49.0% of transferred pediatric trauma patients met criteria for secondary overtriage (no operation, discharge in less than 48 hours, and ISS less than 15). [19] In the Washington State data, 39.3% of transfer patients satisfied the Dartmouth criteria for overtriage.

To date, available literature on secondary overtriage employs analyses of trauma patients as a single group and has reported a proportion of all transfer patients that meet *a priori* criteria.

While this approach is informative, it does not establish a comparison, or unexposed population for analysis. None of these studies provide data on patients who were *not* transferred, the group that is likely to represent the most helpful comparison. To our knowledge this is the first comparison that treats transfer status as an exposure among pediatric blunt solid organ injury patients; we compared patients who were exposed (remained at a lower level trauma center) to patients who were not exposed but could have been (i.e. transferred). These data are also informative in highlighting the potential utility of injury-specific approaches to secondary overtriage. The previously mentioned literature that considers trauma patients regardless of injury type use length-of-stay and ICU admission for definitions of secondary overtriage.[16,18,19] Our findings suggest length-of-stay varies according to transfer status, and ICU length-of-stay is brief and may have limited utility for over 80% of transfer patients. Taken together, specifically for isolated pediatric low-grade blunt solid organ injury, ICU admission and length of stay may be poor indicators of need for transfer.

Our results inform the discussion around transfer for low-grade pediatric solid organ injury in several important ways: 1) Over half of these patients are being cared for at Level 3-5 trauma centers and survival is not significantly different compared to patients who are transferred, 2) There is no evidence that patients who remain at lower level trauma centers undergo operative intervention more frequently, 3) Splenic salvage at Level 3-5 trauma centers is occurring, 4) The data does not suggest that patients with low grade isolated liver, kidney or spleen injuries have lower mortality or lower risk of operation if transferred, and 5) Transferred patients stay longer in the hospital potentially unrelated to clinical factors. Such an approach is not likely to increase imaging, because graded solid organ injury diagnosis is only reached after obtaining advanced imaging. The regionalized trauma system can respond to these findings by exploring additional options to transfer for low-grade isolated blunt solid organ injury such as telemedicine consults with trauma surgeons, pediatric surgeons, and pediatric intensivists, updates to staffing at lower level trauma centers, and the development of state-wide pathways for specific injuries and severities.

These data have limitations. Large datasets over extended time periods are victim to inconsistencies in reporting and data quality and there may be inconsistency in injury coding across the different levels of trauma center. The single patient that expired likely had additional lethal injuries not captured by the trauma registry and may be misclassified as someone with an isolated liver injury. These datasets also lack information on physical exam and imaging characteristics that play a critical role in the clinical decision making for trauma patients with abdominal injuries. Limitations in the Washington State Trauma Registry data made discerning the exact timing of images impossible and therefore difficult to analyze. Vital sign data is only provided for the initial evaluation in the emergency department and may change dramatically over the hospitalization. Transfusion of blood products was considered but not included in final analysis because of high levels of missingness in the trauma registry. Lastly, hospitals may vary in important ways that are not captured by trauma designation but that influence decisions to transfer.

Conclusion

Blunt isolated pediatric low-grade solid organ injury has an excellent prognosis in Washington State and most are cared for at lower level trauma centers. Transfer for the types of injuries examined is associated with additional time in the hospital. The risk of having surgery and the risk of total splenectomy for patients who remain at lower level trauma centers is no different than patients who are transferred. Regionalized trauma systems stand to benefit from tailored pathways that potentially include telemedicine for injuries with an excellent prognosis and potentially few interventions.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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Figure 1. Transfer and Non-Transfer Patients in Isolated Low-Grade Pediatric Blunt Solid Organ Injury in Washington State, 2000-2014

Blue indicates definitive care at a Level I or II trauma center, green indicates definitive care at a Level III-V trauma center

Figure 2. ICU Length of Stay, Proportions of Patients by Transfer Status

Figure 3. Results of Sensitivity Analyses in Fully Adjusted Models

Table 1
Characteristics of low-grade blunt solid organ injury patients by transfer status,
2000-2014 (N=1177)

Characteristics	Triaged from Field to Level I or II Trauma Center (N=226) N (%)	Triaged from Field to Level III-V (N=951)		X ² , p-value
		Stayed at Level III-V Trauma Centers (N=600) N (%)	Transferred to Level I or II Trauma Center (N=351) N (%)	
Male	165 (73.0)	454 (75.8)	260 (74.1)	
Age, years				
0-4	30 (13.3)	48 (8.0)	44 (12.5)	p=0.01
5-9	47 (20.8)	135 (22.5)	104 (29.6)	
10-14	110 (48.7)	277 (46.2)	145 (41.3)	
15-16	39 (17.3)	140 (23.3)	58 (16.5)	
Race				
White	160 (86.5)	390 (86.7)	289 (88.7)	p=0.61
Black	9 (4.9)	13 (2.9)	10 (3.1)	
Native American	0 (0.0)	4 (0.9)	4 (1.2)	
Asian	5 (2.7)	10 (2.2)	8 (2.5)	
Other	11 (5.9)	33 (7.3)	15 (4.6)	
ISS				
< 9	148 (65.5)	424 (70.7)	173 (49.3)	p<0.001
9-16	74 (32.7)	169 (28.2)	172 (49.0)	
16+	4 (1.8)	7 (1.2)	6 (1.7)	
Payer*				
Private	48 (21.2)	116 (19.3)	76 (21.7)	p=0.01
Public	145 (64.2)	439 (73.2)	252 (71.8)	
None	33 (14.6)	45 (7.5)	23 (6.6)	
Injury Types				
Spleen	103 (45.6)	357 (59.5)	166 (47.3)	p<0.001
Liver	89 (39.4)	143 (23.8)	130 (37.0)	
Kidney	34 (15.0)	100 (16.7)	55 (15.7)	
Admission Year				
2000	21 (9.3)	44 (7.3)	19 (5.4)	p=0.33
2001	17 (7.5)	39 (6.5)	21 (6.0)	
2002	13 (5.8)	50 (8.3)	25 (7.1)	
2003	23 (10.2)	38 (6.3)	29 (8.3)	
2004	18 (8.0)	49 (8.2)	30 (8.5)	
2005	23 (10.2)	38 (6.3)	17 (4.8)	
2006	15 (6.6)	51 (8.5)	33 (9.4)	
2007	19 (8.4)	54 (9.0)	26 (7.4)	
2008	10 (4.4)	42 (7.0)	24 (6.8)	
2009	10 (4.4)	33 (5.5)	29 (8.3)	

Characteristics	Triaged from Field to Level I or II Trauma Center (N=226) N (%)	Triaged from Field to Level III-V (N=951)		X ² , p-value
		Stayed at Level III-V Trauma Centers (N=600) N (%)	Transferred to Level I or II Trauma Center (N=351) N (%)	
2010	15 (6.6)	48 (8.0)	19 (5.4)	
2011	11 (4.9)	37 (6.2)	24 (6.8)	
2012	7 (3.1)	20 (3.3)	19 (5.4)	
2013	12 (5.3)	36 (6.0)	18 (5.1)	
2014	12 (5.3)	21 (3.5)	18 (5.1)	

* Public (medicaid and medicare); Private (private insurance, HMO, health care service contractor, labor and industries); None (insistence charity/self)

Table 2
Selected clinical characteristics and outcomes by transfer status

		Triaged from Field to Level I or II Trauma Center (N=226) N (%)	Triaged from Field to Level III-V Trauma Center (N=951)		Fisher's Exact, p-value
			Stayed at Level III-V Trauma Center (N=600) N (%)	Transferred to Level I or II Trauma Center (N=351) N (%)	
CLINICAL CHARACTERISTICS					
Systolic hypotension at ED admission		6 (2.7)	23 (3.8)	5 (1.4)	0.10
Heart Rate at ED admission					
Normal heart rate		183 (81.7)	487 (81.6)	270 (82.3)	0.27
Bradycardia		2 (0.9)	18 (3.0)	4 (1.2)	
Tachycardia		39 (17.4)	92 (15.4)	54 (16.5)	
Missing		2	3	23	
Glasgow Coma Score					
14-15		214 (98.2)	527 (99.4)	317 (99.7)	0.03
9-13		3 (1.4)	0 (0.0)	1 (0.3)	
3-8		1 (0.5)	3 (0.6)	0 (0.0)	
Missing		8	70	33	
OUTCOMES					
Survived		225 (99.6)	600 (100.0)	351 (100.0)	0.19
Surgery		9 (4.0)	25 (4.2)	6 (1.7)	0.09
Length of stay (LOS) categories					
LOS < 24 hours		51 (22.6)	350 (58.3)	27 (7.7)	<0.0001
24 hrs	LOS < 48 hrs	58 (25.7)	74 (12.3)	114 (32.5)	
48 hrs	LOS < 72 hrs	48 (21.2)	69 (11.5)	81 (23.1)	
	LOS ≥ 72 hrs	69 (30.5)	107 (17.8)	129 (36.8)	

Table 3
Regression analysis comparing patients remaining at Level III-V trauma centers to
patients transferred to Level I or II trauma centers

		Unadjusted	Adjusted
Risk of Staying an extra day in the hospital *			
	LOS (days) Median (IQR)		
Transferred	2 (1-3)	1.00 (ref)	1.00 (ref)
Stayed at Level III-V Trauma Center	0 (0-2)	0.71 (0.46-1.11)	0.63 (0.45-0.88)
Risk of abdominal operation *			
	any abdominal surgery/total patients		
Transferred	6/351	1.00 (ref)	1.00 (ref)
Stayed at Level III-V Trauma Center	25/600	2.44 (1.01-5.89)	2.19 (0.80-6.01)
Risk of splenectomy among spleen injuries undergoing surgery **			
	splenectomy/total splenic operation		
Transferred	2/3	1.00 (ref)	1.00 (ref)
Stayed at Level III-V Trauma Center	13/19	1.03 (0.43-2.47)	0.84 (0.32-2.16)
Risk of splenectomy among all spleen injuries **			
	splenectomy/isolated spleen injuries		
Transferred	2/166	1.00 (ref)	1.00 (ref)
Stayed at Level III-V Trauma Center	13/357	2.79 (0.63-12.34)	2.26 (0.42-12.04)

* adjusted for age, organ, ISS, AIS, year

** adjusted for age, ISS, AIS, year